AIR WEATHER SERVICE MANUAL

WEATHER

APPLIED MILITARY CLIMATOLOGY

15 MAY 1968

UNITE STATES AIR FORCE

22

FOREWORD

Applied military climatology is one of the most useful support services that Air Weather Service provides. Unlike weather forecasts, climatological probabilities are not limited to a specified future period. For this reason, applied climatology is especially applicable to planning military operations, determining the optimum course of action when weather is a factor, and solving problems of environmental effects in design, engineering, training, operational procedure, and location.

During recent years, AWS has pursued the improvement of old and the development of new techniques to meet requirements of supported military units. This effort is perpetual. Consideration of natural aerospace environmental factors by planners and operators of new weapon systems continually discloses the need for new and ever-changing applications of climatology. Only through this continuing effort can we provide effective climatological support to our customers.

While the applied climatologist is a meteorological specialist, well-trained in the problem-solving technique and provided with an abundance of meteorological information to resolve a variety of problems, his is not the only contribution to an effective climatological program. The weather observer who constantly gathers and records the basic observations, the duty forecaster who integrates climatological summaries into his daily forecast computations, staff weather officers and detachment commanders who maintain direct contact with the many organizations that need and use the service are all vital to successful climatological efforts.

This manual explains for Air Force meteorologists the concepts of applied climatology and the overall AWS Climatic Service Program. It discusses the services that are available and the manner in which assistance can be obtained. It is this basic knowledge that will allow all Air Force weather personnel to participate actively in this important field.

Since it is only through our combined efforts that the full potential of the AWS Climatic Service Program can be realized, I urge all Air Weather Service personnel to familiarize themselves with the contents of this manual.

RUSSELL K. PIERCE, JR., Brigadier General, USAF
Commander

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Headquarters
AIR WEATHER SERVICE (MAC)
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Weather

APPLIED MILITARY CLIMATOLOGY

PURPOSE: This manual provides AWS meteorologists with information concerning the AWS Climatic Service Program. It outlines mission, organization, procedures, and concepts of an applied military climatological service. This manual is not intended to provide a complete discussion of climatic analysis techniques or statistical procedures, as these subjects are adequately presented in other publications.

(See summary of revised, deleted, or added material below signature element.)

CONTENTS

*This manual supersedes AWSM 105-3, 1 Aug 1961 and AWSM 105-3A, 6 Aug 1965.
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Distribution: X (Continued on page iv)

Chapter 1

AWS APPLIED MILITARY CLIMATOLOGY

1. **General:**

a. The expansion of the military weather service necessitated by the magnitude of operations during World War II led to the organization of the first military climatological unit in the United States. This first organization was patterned after those of other national meteorological services that were involved in statistical processing of meteorological observations, summarizing results, and publishing data in various forms. At that time, the standard practice was to employ the classical, or descriptive, climatological approach wherein the climatologist presented only a general account of weather conditions over an area along with voluminous tables, or an analytical approach, to find a physical explanation of the climate. Experience soon proved that this practice was totally inadequate for solving the complex problems of military operations, though it might satisfy certain general intelligence purposes. As a result, the need was established for a meteorological agency that would be capable of accepting an operational problem, analyzing it, determining the proper meteorological information to apply to it, and formulating an answer in terms of the problem itself [1]. Subsequently, the underlying philosophy and principles of an efficient and effective military climatological organization were developed (see Table 1). The USAF Environmental Technical Applications Center USAF (ETAC), organized in 1964 from the former AWS Climatic Center, is the present, primary climatological organization within the AWS.

b. To keep pace with technological advancements of the "Space Age," overall capabilities of USAF ETAC have increased significantly over the years. Substantial increases in highly-skilled, well-qualified personnel have been made, and increased automation, through continued acquisition of sophisticated electronic computers, has greatly enhanced the ability of USAF ETAC to respond rapidly and efficiently to the myriad of requests resulting from the tremendous growth of military technology. A continuing effort is necessary to insure that climatological "know-how" keeps pace with and exploits technological advances of other sciences.

TABLE 1

Principles of Applied Military Climatology

- Applied military climatology is a staff function.
- The examination of the sensitivity of plans and designs to environmental conditions must begin with the initial stage of planning.
- Solutions or recommendations to a military planning or design problem must be determined by a systematic and scientific analysis of all factors bearing on the problem.
- Solutions must be presented in terms of the operation or problem involved.

c. Indicative of this continuing effort are recent expansions within the AWS climatic program. Solar-geophysical data collected by the AWS Solar Observations and Forecasting Network (SOFNET) are stored at

USAF ETAC's Data Processing Division, Asheville, NC. These data consist of the following observations: (1) solar flares, (2) solar hydrogen and calcium plages, (3) sunspots, (4) geomagnetic variation data, (5) ionospheric data, (6) solar radio maps (3 mm), and (7) solar radio-flux observations. A Rocketsonde Branch has been added to the Aerospace Sciences Division of USAF ETAC; its primary responsibilities are: (1) to receive original rocketsonde and associated rawinsonde records, check and reduce rocketsonde data, and compute pressure, density, and speed of sound values, (2) exercise quality control over the rocketsonde observations, (3) establish realistic observational standards, (4) provide automated programs for data reduction and quality control, and (5) develop applications and technical studies to improve accuracy and usefulness of the data. These data both raw and processed, are stored in readily accessible format at the Data Processing Division.

d. The natural aerospace environment is recognized as one of the most important uncontrolled variables affecting military operations. Consequently, climatological analyses of this environment are among the more important services provided by AWS. Operations must be adapted to their environment to maximize advantages that can be gained from favorable weather, and to minimize risks inherent in unfavorable weather. Weather observations and long- and short-range synoptic forecasts are limited to specified periods of time and, therefore, are useful for current operations and short-range planning. On the other hand, the accuracy of a climatological forecast is generally independent of lead time and is effective for long-range requirements. While this manual is concerned with applied aspects of climatology, efficient climatological service is not limited to applied techniques alone, but also can involve an optimum mixture of applied, descriptive, and synoptic climatology.

2. Definitions of Applied, Descriptive, and Synoptic Climatology:

a. Applied climatology is the scientific analysis of climatological data in the light of a useful application for a practical purpose. It is the primary weather service supporting long-range operational planning.

b. Descriptive climatology is the production of generalized reports on the climate of a geographical point or area, or a particular aspect of climate. It may serve as an adjunct to applied climatology in the sense of a problem-determining function for long-range, strategic planning by providing preliminary orientation on climatic features that can generate practical problems.

c. Synoptic climatology can be defined as the analysis of the climate in terms of synoptic weather tracks or patterns, usually taken from analyzed synoptic charts. Information determined in this way gives the average weather (climate) of a particular place for a specified synoptic situation, rather than average values based on all synoptic situations. It is mainly useful as an adjunct to weather forecasting and applied climatology.

3. Objective of the AWS Applied Military Climatology Program:

a. While the original climatological organization of the AWS has been renamed, reorganized, and relocated several times since its inception, philosophy and principles governing the climatological service (Table 1) have not changed. The objective of the AWS climatology program remains:

> "To provide advice and quantitative information on natural environmental effects within the aerospace by means of consultation, processing, analysis, and interpretation of recent and past environmental information."

b. The present-day concept of applied military climatology is geared to aid in the solution of many and various problems in which natural environmental effects are a factor. These problems range from those that may be solved at the base weather station, using limited reference material, to those that require the assistance of specialists, vast amounts of data, and the use of modern electronic data processing systems.

Chapter 2

ORGANIZATION OF THE AWS CLIMATIC SERVICE PROGRAM

4. Introduction:

a. Climatic service to military agencies must be designed specifically to solve their individual problems; it must be accurate and rapid enough to meet their requirements. Such support dictates an organization with extensive technical capabilities in personnel and equipment; rapid, dependable access to specialized data; and fast, flexible data processing.

b. The USAF Environmental Applications Center is the centralized analysis facility that provides this support. With the exception of its Data Processing Division, which is located in Asheville, NC, USAF ETAC is located in Washington DC. Figure 1 depicts the organizational structure of USAF ETAC.

c. The organization of a centralized climatic center within the AWS has not removed the requirement for smaller climatological units at wing, group, and squadron headquarters. Nor has it relieved commanders of AWS units of their responsibilities to service the climatic needs of their supported commands. On the contrary, detachment meteorologists and staff weather officers of the various units and commands remain primary links between the AWS and its customers. These individuals must receive and coordinate the bulk of climatic requests, consult with and advise requesting units on climatological matters, and provide in final form the necessary facts to satisfy requirements of operational units. Limited only by the extent of local reference and data files and data processing equipment, each climatic unit within the AWS has the capability to produce or obtain and furnish answers to climatic requests.

5. The USAF Environmental Technical Applications Center USAF (ETAC):

a. Mission. USAF ETAC's organizational structure is designed to perform effectively the following mission.

(1) Provide a centralized USAF capability to collect, store, retrieve, and process historical aerospace natural environmental data for planning and technical applications.

(2) Recommend, evaluate, elaborate, and adapt existing, improved, or new techniques for the production and application of aerospace natural environmental information.

(3) Provide advice and quantitative data on aerospace natural environmental factors that affect military weapons, facilities, operations, and plans to Department of Defense activities (excluding the US Navy), and other agencies as directed, in accordance with priorities established by the Commander, Air Weather Service (MAC).

(4) Provide centralized scientific information and publication services.

(5) Edit and prepare for printing AWS manuals, technical reports, and the Aerospace Sciences Review; catalog and maintain a file of technical publications of AWS field units; and support field needs for library service.

(6) Generate studies and projects deemed necessary to improve capabilities to accomplish the stated mission.

b. Processing Requests. The system developed by USAF ETAC for processing requests for service is shown in Figure 2, a schematic representation of the stages through which a request is processed as it moves through the Center from receipt to completion.

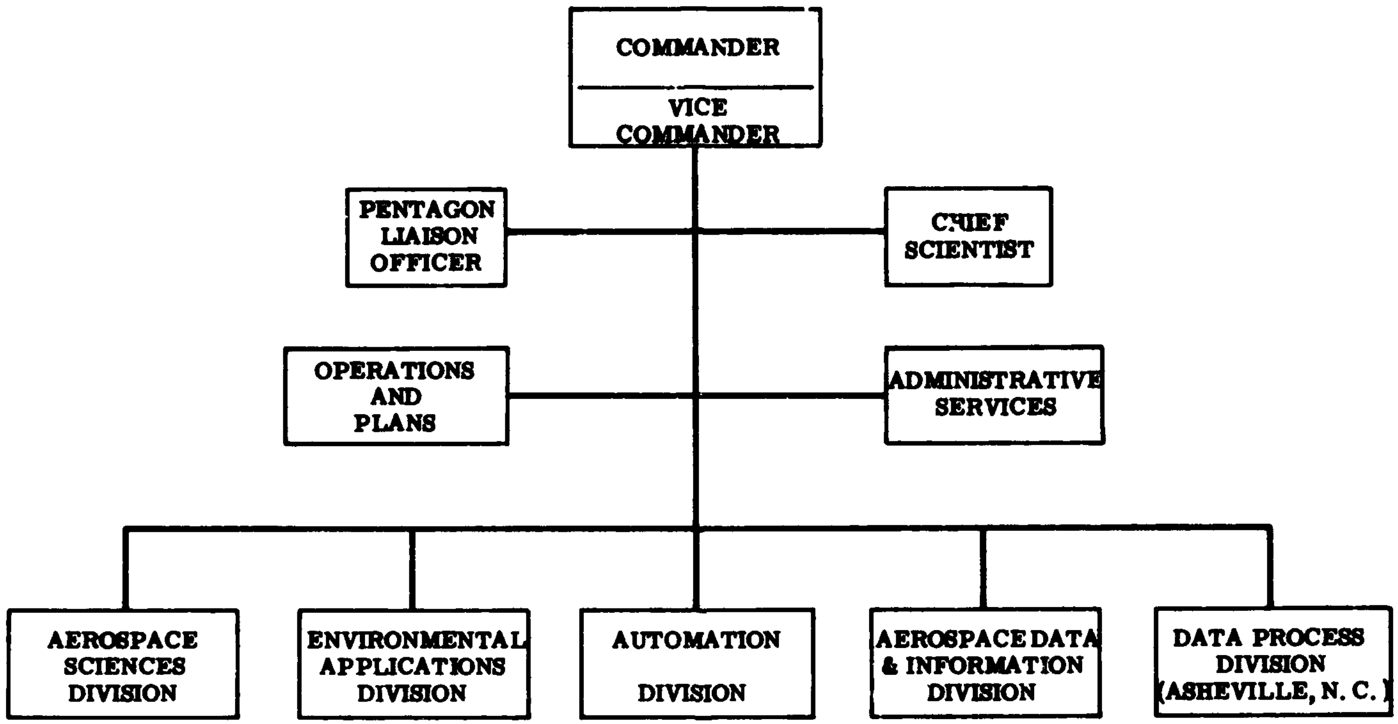

Figure 1. The USAF Environmental Technical Applications Center.

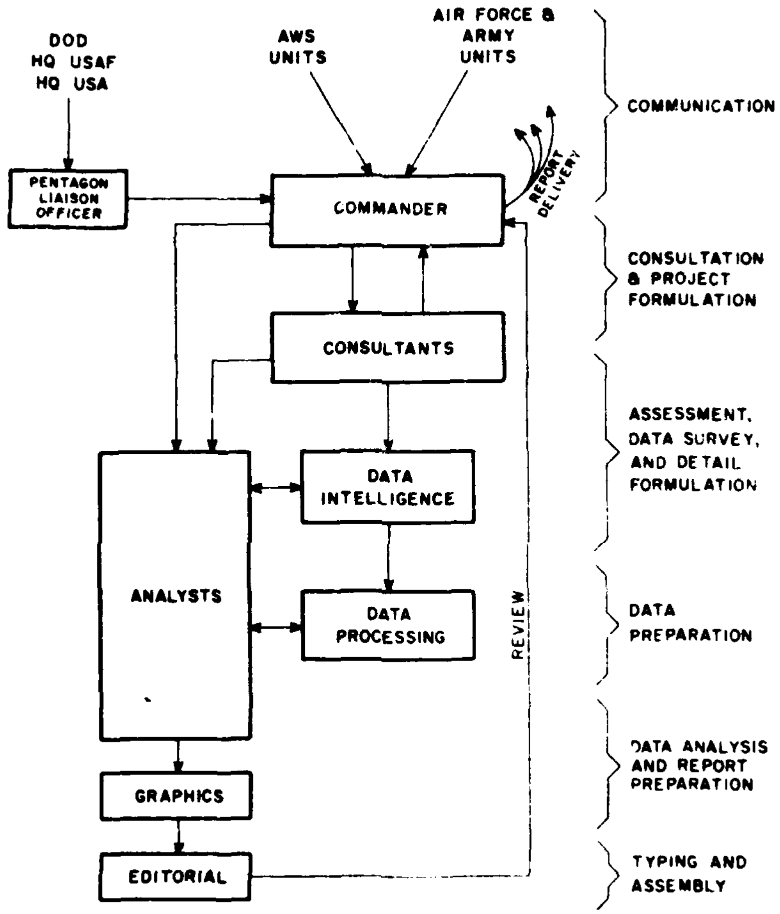

Figure 2. Project Flow Chart at USAF ETAC.

(1) USAF ETAC's service is provided only on request. A request can be transmitted to the Center by telephone, letter, or electrical message. If a request is expected to require less than two hours to fulfill, it is processed immediately. To insure adequate management during processing, a request that requires more than two hours to complete is assigned a project number, priority, and specific or estimated completion date. USAF ETAC policy dictates that all requests requiring project numbers be presented in writing. This does not preclude immediate action on a telephonic request that requires rapid service, but the request must be confirmed by a written communication, in accordance with AWSR 105-7.

(2) During the consultation and project formulation stage, the request is studied to diagnose and define the problem. This stage may involve conferences with the requester to insure that the Center has identified and understands the problem and that all factors concerning it are considered.

(3) Next, a project officer, who has full responsibility for the project until a solution is forwarded to the requester, is assigned. He establishes the production schedule, surveys available data and information sources, and formulates the analysis program.

(4) After selecting those data and information that will provide the best solution, the project officer arranges for the processing of selected materials into a format compatible with his analysis program. Machine processing may be required during this stage.

(5) When the analysis of processed information is complete, a draft of the report to the requester is prepared. The report may contain conclusions, solutions, recommended actions, graphical materials and/or data tables. The draft report undergoes a final review for technical competency, appropriateness, and sufficiency before it is typed for submission to the requester.

(6) Whenever possible, a final consultation with the requester is held to insure that the report is interpreted correctly and answers his problem satisfactorily, and to provide for any additional services generated by the report.

6. Services Provided by an AWS Wing, Group, or Squadron:

a. There are considerable variations in missions, interests, and methods of operation of the major commands. These variations result in large differences in the climatological support provided by AWS wings, groups, or squadrons. Some climatological units have been allocated large staffs, while others have few personnel; some are equipped with complete electronic data processing facilities, while others have none.

b. A wing, group, or squadron commander is responsible for providing climatic services to his supported command. Therefore, a commander must be aware of planning and operational problems confronting staffs of both supporting and supported organizations, and recognize situations that require consideration of the weather factor. The weather commander's responsibility does not end with the recognition of a requirement for climatic service; he must arrange for the capability to provide the required support. Capability includes personnel, data and meteorological reference materials, techniques for analyzing data, and communications. The following functions are common to climatological sections of wings, groups, and squadrons:

(1) Consultant to the weather commander, his staff, and field unit commanders on climatological matters.

(2) Consultant to the staff of the supported major command on climatological matters.

(3) Maintenance of basic reference materials.

c. The following are typical areas of climatic support provided to a major command with world-wide interests, with weapon systems that include missiles, manned bombers, and tankers, and with an interest in tactical and naval operations:

(1) Emergency war plans.

(2) Peacetime operations.

(3) Construction and engineering.

(4) Applied development and test of new systems (reference materials required for adequate support):

(a) Reduction of required weather data from available data.

(b) Special techniques for data analysis.

(c) Electronic computer programs and subroutines for solving planning problems.

(d) Computer programs for presenting planning factors in a format most readily usable by the planner.

(5) Operations analysis.

7. Services Provided by an AWS Detachment:

a. At the detachment level, the commander is a climatological consultant to the base commander and tenant units. Working with the base commander's staff, the detachment commander advises on the many ways weather can be used in staff planning. He is responsible for making this service known to base personnel and for stressing the importance of considering environmental effects in long-range planning, whether it involves operations, design and layout of equipment, use of resources, or determination of policy. As a staff meteorologist, he must be aware of daily operations and future plans of supported organizations so he can provide advice on uses of climatic services.

b. Climatological data and information available within a detachment may be limited to only standard summaries for the local area. These summaries contain sufficient data to answer many local requests for assistance. When a detachment cannot satisfy a request for service within its own resource, the request is processed in accordance with AWSR 105-7, Climatic Service, for considerable data and technical information are available at most squadron, group, and wing headquarters

Chapter 3

APPLIED MILITARY CLIMATOLOGY PROBLEM-SOLVING PROCESS

8. Introduction:

a. Welding "weather" and "planning" or "operational" organizations into a smooth working team is not accomplished overnight or by the publication of orders and organizational and functional charts. Acquiring clear-cut procedures for establishing good working relationships and accomplishing objectives come only with time, effort, and experience.

b. Applied military climatology provides a technical approach that changes consideration of complex environmental factors from a crude, subjective, or intuitive process to an objective problem-solving and decision-making one. This encompasses the analysis of a proposed design, plan, or course of action in the natural aerospace environment it will encounter. One purpose of this analysis is to establish the effect of the various weather factors. Another objective is to identify the optimum choice of action by presenting several alternatives and their respective weather-dependent probabilities of success.

c. Each problem must be given adequate thought. A quick answer that does not solve the problem completely or satisfactorily can be dangerous; it may conceal the existence of serious consequences and, in any case, fail to provide the planner or operator with the most useful and applicable information. On the other hand, the problem may not deserve the most exhaustive effort, but only a careful consideration can justify such a decision. The constant use of sound procedures in problem solving is the only way that the weather officer can fulfill the mission of providing a satisfactory and, at the same time, efficient climatological service to the organization he supports.

d. In every case then, when the meteorologist is confronted with a planning problem involving weather, some logical problem-solving procedure must take place. Figure 3 illustrates normal procedures for consulting, processing, and resolving phases used in solving military climatological problems. With this, or a similar process, the meteorologist assures himself (and his customer) that he is providing the best possible climatic service.

9. The Meteorologist as a Climatological Consultant:

a. The consulting meteorologist may be a specially-trained climatologist, an atmospheric scientist, a staff meteorologist (or "STAFFMET"), or a detachment commander serving in a staff capacity to operational units located at his station. In any case, he belongs to two teams, the AWS and the unit he supports; he has responsibilities to both. He occupies a key and pivotal position that must be recognized and exploited to the fullest extent. This means, on the one hand, that he must be familiar with the capabilities of climatological procedures and support that can be provided and, on the other hand, that he must know capabilities, objectives, doctrines, plans, and procedures of the organization he supports. His first task is to discover weather effects on operations of the unit supported. To be fully effective, he must anticipate requirements for climatological service, for the operational staff may not be fully aware of how weather information can be used. The meteorologist must seek out every phase of operation and planning that can be aided by a climatological consideration of the weather factor. As a consultant, he must have knowledge of data,

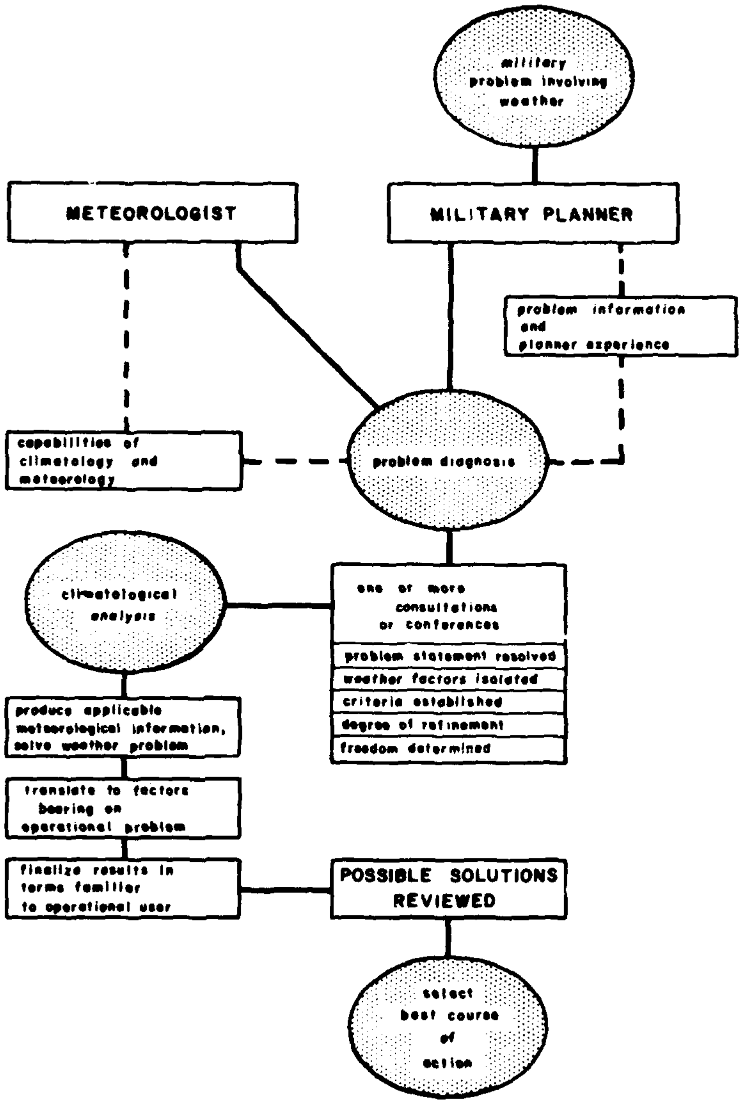

Figure 3. The Problem-Solving Process.

facilities, and techniques of the AWS Climatic Service Program, upon which he can call for technical assistance.

b. Consultation in applied climatology calls for judicious employment of a combination of technical knowledge, salesmanship, and diplomacy. Consultation requires the rapid perception of all key details of an operational or design problem, the translation of the problem into meteorological terms, and the ability to design a procedure and format for a solution in operational terms of the requester. The experienced consultant gains a rapid insight into problem areas and gauges the technical level at which a proposed solution should be presented. He must face a great variety of problems, as well as diversity in backgrounds of the requesters.

c. The consultant deals largely with nonmeteorologists. Because of a lack of technical knowledge of meteorology, most requesters, by themselves, find it difficult to translate their problem into meaningful meteorological terms. The consultant should help the requester to define the problem, and convince him of his interest and desire to help. The discussion should move along at the requester's pace.

d. Through personal contact, the consultant learns the general problem, including the mission to be accomplished, equipment to be used, and environmental limits for varying degrees of degradation of equipment and plans. His next step is to study the details of the problem thoroughly, encompassing specific geographical areas, altitudes, and terminals, in order to diagnose and analyze the problem correctly. Finally, the consultant should give, if appropriate, the requester the recommended solution in terms of the probabilities of success for a variety of alternatives. And, the solution must be stated in terms the user understands.

e. While the initial request for climatological information may be by correspondence, the consultant must remember that an exchange of written communications to arrive at the details of the problem is probably the least efficient method of those available to him. Besides the delay in exchanging written questions and answers, semantics also can be a serious block, especially with correspondence between a meteorologist and a non-meteorologist. A personal visit with the requester, if possible, or a telephone contact, if authorized, is much more effective.

f. Often it is desirable, at an early stage, for the consultant to provide the requester with a "mock-up" of the format of the solution. If, after some effort, the problem cannot be formulated completely, the consultant should offer to provide at least a first approximation study — a commitment to a final study to be agreed upon after preliminary climatic analysis. Ultimately, there should be follow-up action to insure optimum use of the information provided and to uncover further problems.

10. The Military Planner:

a. Usually, the military planner is located in the Plans, Operations, or Intelligence staff section, but he could be an installations officer, a design engineer, a staff officer, or a field commander.

b. Planners may be grouped into three categories: (1) those who have problems they know involve weather and fully coordinate their weather problems with the meteorologist; (2) those who request large amounts of climatic data without stating their problems; and (3) those who have inadequate or incorrect, preconceived notions of the information to be applied to their problems and the application or interpretation of criteria. Fortunately, most requesters for services fall within the first category, and only a small percentage within the second. Unfortunately, many fall within category three and cause the meteorologist much difficulty during the consultant phase. For example, a planner placed on USAF ETAC a requirement for the monthly percentage frequencies of 3/10 or less cloudiness over a specified area. After being questioned about the nature of the problem, he divulged that it was for aerial photography, but was hesitant to supply details. After considerable, tactful persuasion on a "need-to-know" basis, the facts bearing on the problem were finally determined. Actually, the planner wanted to know the month that has the highest frequency of 3/10 or less cloudiness below 20,000 feet during hours suitable for aerial photography. This was provided readily. The planner could have been furnished the data originally requested without much effort, but the information would not have led to the proper solution to his problem.

c. The more accurately a planner states the nature of his problem, the better equipped the meteorologist is to provide a tailored, climatological analysis and solution. Information requested by a planner may or may not be close to that actually needed; but, when the meteorologist has knowledge of all facts bearing on a problem, he can use the most applicable meteorological data to obtain the best solution.

d. Sometimes weather is a major factor to be considered in the planning of operations — sometimes it is relatively unimportant. But, important or unimportant, it should not be ignored. Even though a planner feels he has little need for incorporating the weather factor in his decision, he should be cognizant of weather effects, for sometimes the inclusion of the weather factor points out a better way to perform an operation or indicates that an operation is not feasible.

11. Problem Diagnosis:

a. Applied climatology is a form of operations analysis, concentrating on decision points and processes involving environmental considerations in long-range planning. The two main activities in the process are (1) diagnosis of the operational or planning problem, and (2) interpretation of environmental factors in terms of effects and indicated actions. The principal lines of attack are a direct approach to analysis and solution of the planning problem and an indirect approach to evaluation of the intended or possible use of the climatic information. In all cases, a request for a long-range forecast or climatic data is considered only a clue that someone has a problem. The problem must be defined before the climatologist can determine how it can best be solved. Criteria for climatic information generally depend on the operational application to be made, rather than the intrinsic character of climatic data. Most problems require an answer in operational terms, showing a risk, performance level, time, location, or method of operation to achieve the mission objective.

b. Problem diagnosis is the total analysis to determine the exact nature of the problem. Projects of limited scope are simple to delineate. The more involved and detailed the problem, the more difficult it is to make a precise statement. One of the first actions in a conference or discussion is to resolve and phrase the problem as a question or statement. Conferences and discussions, of course, should follow accepted conference techniques closely.

c. An exact statement of the problem is of primary importance to the meteorologist, for it determines the type of information to be used in the analysis. The statement of the overall problem is often broken down to sub-problems; this is necessary in broad investigations. Each subproblem statement may involve weather, so several climatic analyses may be necessary.

d. After the problem statement is resolved, the next steps are to list definitions and assumptions, and to select criteria. At this point, the meteorologist should have the weather portion of the problem isolated and stated in terms of the problem. This leads to a determination of environmental criteria applicable to the problem and acceptable to conference members. Then, the meteorologist should ask himself, "If this information is applied to the problem, will the environmental factor be delineated completely?" Further consideration may seem desirable, and the meteorologist may decide to restate the criteria.

e. Tables 2 and 3 contain checklists to assist in the definition of operational problems and design problems, respectively. These checklists are not all inclusive, but they can be applied to most climatological requests. The chapter on Applied Climatology in the *Compendium of Meteorology* contains a comprehensive discussion of various climatological problems [2].

TABLE 2

CHECKLIST TO ASSIST IN THE DEFINITION OF AN OPERATIONAL WEATHER PROBLEM
(after Jacobs, unpublished)

1. Is the request being received directly from an operational planner, or is it being passed along through indirect channels?

2. If indirect channels are being used, does the requester appear competent to pass along and discuss the requirements of the agency needing the service?

3. What operational subdivisions exist in the general problem area described? (There may be two or more problems instead of one.)

4. Class of problem:
   a. To lead to a design or specification (what?)
   b. To establish a procedure (how?)
   c. To make an operational decision (where? when?)

5. How does the prospective user of the weather information define his weather problem?

6. How does he define his operational problem?

7. Who is going to make a decision on the matter, and what is the nature of the decision this individual (or group) is being called on to make?

8. Do the answers to 5, 6, and 7 appear compatible? If not, why not?

9. What degree of freedom for decision is allowed by nonmeteorological factors?

10. Have solutions been obtained for analogous operational problems?

11. If not, are operational figures (test, operational, performance) available for correlation purposes? For what periods (years, months, dates, hours)?

12. Can the operational problem be redefined in more realistic meteorological terms?
    a. What are the critical weather limitations to the operation?
    b. Is it important to stay within critical limits, or is it a problem requiring maximum operating conditions?

13. Have all operational criteria been firmly established?

14. Can I now explain the operational problem to the planner's satisfaction?

15. Does he approve a "mock-up" of the results as I plan to present them?

16. When is the decision to be made, and what is the minimum lead time required?

TABLE 3

CHECKLIST FOR A DESIGN PROBLEM
(after Jacobs and Spreen, Bulletin of the AMS, Vol. 34, No. 10, 1953)

I. What are the space and time functional requirements?
   1. Where in the aerospace will the equipment operate?
      a. Operation at a point.
         (1) Specific point or points.
         (2) General or unspecified points.
      b. Operation over an area.
         (1) Geographic, topographic, altitude.
         (2) Combinations of geographic, topographic.

   2. In what time period will it operate?
      a. Year, season, month, day, hour.
      b. Combinations of year, season, month.

II. What operational efficiency is required?
   1. Will a calculated risk of inoperation be acceptable?
      a. If No — operation is required under all conditions.
      b. If Yes — a certain percentage of inoperativeness is acceptable.
         (1) Is the inoperativeness an areal concept?
         (2) Is the inoperativeness a time concept?
         (3) Is the inoperativeness an area-time concept?
         (4) Is the inoperativeness an economic concept?

   2. What duration of operation is required?
      a. Is the operation continual?
      b. Is the operation periodic?
         (1) Is the periodicity regular and specific?
         (2) Is the periodicity intermittent?
            (a) Can period be selected?
            (b) If not, is intermittent period random?

f. After criteria have been established, the degree of refinement or order of accuracy of data needed to solve the problem must be determined. Quite often, accuracies of data requested are far beyond the real requirements. For example, when using the number of days per month of a given phenomenon, will whole days suffice, or is it necessary to furnish whole and part days? Is it necessary to consider temperature to the first decimal place, or will whole degrees be satisfactory? Waste of analysis, editorial, and reproduction time can be eliminated if the accuracy of information desired is specified realistically in the problem formulation stage.

g. Each meteorologist should be able to accept a climatological request and determine the information applicable to the problem. The field meteorologist cannot delegate his responsibility to tackle an operational problem involving a meteorological consideration when it is presented to him. He should diagnose the problem, design the study required to solve it, and, making full use of his own personal skills and local resources, carry the study as far as possible. Then, if necessary or desirable, he should call on the appropriate climatological unit for support.

12. Climatic Analysis:

a. Numerous techniques for solving a variety of climatic problems are available to the analyst. This paragraph is limited to a general discussion of principles and procedures of climatic analysis.

b. Climatic analysis is the process of producing and interpreting environmental information to determine its effect on a particular problem. The problem, or objective of a given analysis, as established by consultation and diagnosis phases, determines the procedure. Climatic analysis results in specific climatological facts that can be applied as factors in testing solutions to operational, design, or planning problems.

c. Climatic analysis demands an active and aggressive approach. That is, climatic analysis becomes effective only when the analyst searches diligently for the best solution within available resources. Merely going through the motions of investigation to justify a preconceived idea or to seek a passable solution with the least amount of effort is not conducive to an effective climatic service. Only the use or development of proper technical tools and the determination of sufficient facts and information during the analysis furnish a final result that stands up under application to the planner's problem.

d. Before starting an analysis, the analyst must be satisfied that the selected method or approach is likely to be the most productive and efficient one. The approach must meet three conditions:

(1) It must be suitable. When completed, it must provide the information necessary to advise the planner or requester competently. The end product must do more than establish a climatological fact — it must show the planner what to do, or it has little value.

(2) It must be feasible. The tools necessary to do the study — data, processing capabilities, statistical techniques — must be available.

(3) It must be acceptable. Costs must be evaluated in terms of money, manhours, and other resources expended. The relative importance and priority of the requester's problem govern the resources that should be allocated to solving it.

e. The style of analysis (and the final report) normally parallels that of a staff study in which there are:

(1) A statement of the problem.
(2) Facts bearing on the problem.
(3) Discussion of the facts.
(4) Conclusions.
(5) Recommended action.

f. Climatic analysis procedures, as with diagnostic conference procedures, demand a high degree of objectivity and avoidance of personal bias. There is no formula for insuring that climatic information is applied impartially, but the ability to select and apply applicable information is an important factor in producing an effective and efficient analysis. As information is accumulated, the analyst must devise a method of grouping the information into units that can be processed in a manner that allows the relationship between different weather conditions or criteria to be evaluated. Extensive facts or data do not contribute to the analysis unless they are systematically organized and their significance clearly pointed out. Facts or data must be arranged so they are meaningful to the customer, their interrelations become apparent, and the whole can be assembled into usable form. Table 4 is a good checklist for analyzing climatic problems.

g. In addition to practices commonly used (by national weather services and academicians) for data summarization, there are many special techniques that can be used in applied climatological analyses. There are almost as many techniques as there are problems.

(1) Established theory, laws, and formulas should be used as much as possible, for they save time and data processing. When they can be applied, there is no need to fall back on original data from which the theory or law was derived.

(2) Empirical methods should be used whenever physical methods are inadequate. They are particularly valuable for transposing meteorological information to operationally useful data. For example, empirical methods have been developed to show probable ice loads on wires and radomes and wind loads on structures and used to bridge gaps in weather observations.

(3) Statistical methods are the most common means of reducing large volumes of data or deriving desired probabilities. But statistics themselves seldom prove a point beyond all doubts; they can suggest whether evidence supports an idea or plan and reveal salient features of a mass of data. There are many sources of statistical techniques. One of the most convenient to the AWS military climatologist is the AWS *Climatic Methods File* [3], which is a compilation of selected statistical procedures that can be used in solving many common climatological problems. Other sources that contain excellent discussions of statistical techniques and examples of their application to meteorological problems are *Methods in Climatology* [4], *Handbook of Statistical Methods in Meteorology* [5], and *Some Applications of Statistics to Meteorology* [6].

(4) Synoptic-climatic methods are used on some projects. They are often the best or only way of attacking complex time and space problems. For instance, the best way to study long air routes, or operations over large geographical areas, from the weather standpoint may be to classify and summarize occurrences of broad synoptic situations according to their overall favorability or unfavorability.

h. Throughout the analysis, while the problem is being resolved and additional information and data are being gathered, the consultant or analyst should think about possible explanations and solutions. But, until the data are evaluated and applied carefully, there is little justification for forming definite conclusions. However, as the analysis progresses, tentative conclusions and recommendations that are based on more than casual conjecture can be formulated for testing.

13. Presenting Results of a Climatic Study:

a. A cardinal principle of applied climatology is that information be presented to the planner in terms he can understand and apply readily. Seldom, if ever, does the planner require large quantities of basic climatological data. He is usually interested only in conclusions and recommendations of the analyst.

b. A formal report of the results of a climatic analysis to the customer is not required necessarily. Often, results are conveyed merely by letter, or by further consultation and coordination with the requester. If a formal report is required, a staff study or a planning estimate, written in standard USAF format, usually suffices. In any case, the analyst should prepare a typed memorandum for the record to summarize what was done and what was given the requester. This record is a valuable reference for analogous problems, which may arise at a later date.

c. When an analysis is prepared for a supported weather unit, the supporting climatological section usually returns the results to the requesting unit in tabular or report form. Upon receipt of the completed study, the unit meteorologist must familiarize himself with the results, assure himself that it answers the problem, and, if possible, deliver it personally to the original requester.

TABLE 4

CHECKLIST TO ASSIST IN THE ANALYSIS OF CLIMATIC DATA
(after Landsberg and Jacobs, Compendium of Meteorology)

1. Class of climatological technique required.

2. What data are desirable?
   a. Elements (pressure, temperature, wind)?
   b. Are combinations of elements required? If so, what combinations? Are their relationships known?
   c. What length of record is needed for an adequate solution?

3. What climatic data are available?
   a. At the spot, in the area, over the region?
   b. In what form are the data? Are existing summarizations suitable?
   c. What length of record is available?
   d. Are climatic data available for the same periods covered by operational information?

4. What are the local peculiarities in climate that can affect the usefulness of existing climatic data?

5. What are the physical or statistical limitations imposed on the data and their interpretation?

6. Does theoretical information (or a suitable technique) exist that can serve to supplement, evaluate, or be substituted for inadequate observational materials?

7. Are solutions available for analogous climatological problems?

8. Is there a need to elaborate a new theory of interrelations?

9. What form of presentation of the conclusions is desirable?
   a. Graphs, tables?
   b. Formulas, alignment diagrams?
   c. Others?

The meteorologist should explain the results, their application and limitations, to the customer. This procedure strengthens the working-team relationship and helps to eliminate misinterpretation or misuse of the study. In addition, the meteorologist should attempt to determine the effectiveness of the study (and therefore the effectiveness of his climatological service) in the planner's selection of a course of action, for this also improves working relationships between the supported and the supporter and increases the capability of the supporter to provide complete services in the future.

Chapter 4

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